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# SMOKE TUNNEL INVESTIGATION OF A FLAP CONFIGURATION DEVELOPED BY CHASE AIRCRAFT CO.

Report No. 245

Project No. NR 212-011 Contract N6 onr-27016


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R. F. Lehnert



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## 1. Summary:

At the request of Mr. A. Satin of the Air Branch, Office of Naval Research, smoke tunnel investigations of a flap configuration suggested by the Chase Aircraft Co. were made in the 2" x 36" Smoke Tunnel located at the Forrestal Research Center of Princeton University. For comparison purposes a study was also made of a similar section equipped with a standard NACA single-slotted flap. The smoke tunnel was able to give a clear picture of the action of both flaps and to suggest means of possible improvement in the Chase flap which when made resulted in its performance being equivalent or slightly superior to the standard NACA flap. Photographs of the flow over the two flaps are included.

## 2. Introduction:

For some time, there has been a growing feeling that the problem of obtaining high lift for certain types of aircraft has become severe enough to warrant the investigation of any modification which holds out any hope of improvement of the situation even though this modification may be in the form of a refinement and the promised improvement small. Accordingly, when on Nov. 2, 1953 Princeton University was contacted by the Chase Aircraft Co. it agreed to make a preliminary investigation utilizing the 2" x 36" smoke tunnel to determine if the suggested flap modification had sufficient merit to warrant detailed investigation. These tests were conducted for O.N.R. Contract No. N6 onr-27016 under which Princeton University is conducting high lift research.

## 3. Discussion:

In order to conduct these tests, Chase Aircraft Co. supplied two models of the NACA 23015 type of 2' chord and 2" span allowing them to be mounted directly in the smoke tunnel utilizing the standard model mount. These models were equipped with plexiglass sides to permit the easy viewing of the flow through the flap tunnels or slots. One of these models was supplied with the standard NACA flap, the other with the Chase flap.

The first tests made were merely exploratory tests made to determine if the smoke tunnel could show the flow phenomena sought and if either flap showed a marked superiority. The results of these tests indicated that the smoke tunnel could in fact be used for this type of investigation and that the NACA flap was considerably superior to the Chase flap in its operation. It was felt that the Chase flap was being penalized by the narrowness of its slot and that if the comparison between the two were to be valid the slot dimensions must be made to coincide. It was also found that the flow tended to separate from the guide vane as it was arranged in the original design. When this was changed from the configuration shown in Fig. 1 to that of Fig. 2 so that it functioned as a hood making the flap behave essentially like a double slotted flap, this separation was to a great extent avoided and the flow tendency to attach to the flap improved.

Having made these preliminary investigations and adjustments, a systematic investigation of the two models was started. Photographs were taken at five different angles of attack for flap deflections of 0°, 20°, 45° and 60°.

at each flap deflection, one photograph depicts what was estimated to be the stall condition. For conditions other than the stall, the two flapped sections were tested at the same angle of attack to make possible a direct comparison. For these tests the test section velocity was arbitrarily set at 30 '/sec.

Figs. 3 to 12 demonstrate typical flow photographs. The key to these photographs is given below:

| Fig. No. | Photograph No. | Flap Type | Flap Deflection | Angle of Attack |
|---|---|---|---|---|
| 3 | 3 | CHASE | 0° | 7°-0' |
| | 23 | NACA | 0° | 7°-0' |
| 4 | 5 | CHASE | 0° | 13°-35' |
| | 25 | NACA | 0° | 13°-35' |
| 5 | 7 | CHASE | 20° | 4°-28' |
| | 027 | NACA | 20° | 4°-28' |
| 6 | 8 | CHASE | 20° | 8°-40' |
| | 028 | NACA | 20° | 8°-40' |
| 7 | 012 | CHASE | 45° | 3°-37' |
| | 32 | NACA | 45° | 3°-37' |
| 8 | 013 | CHASE | 45° | 7°-0' |
| | 33 | NACA | 45° | 7°-0' |
| 9 | 014 | CHASE | 45° | 10°-19' |
| | 34 | NACA | 45° | 10°-19' |
| 10 | 015 | CHASE | 45° | 11°-34' |
| | 35 | NACA | 45° | 11°-34' |
| 11 | 16 | CHASE | 60° | 0° |
| | 36 | NACA | 60° | 0° |
| 12 | 19 | CHASE | 60° | 10°-19' |
| | 39 | NACA | 60° | 10°-19' |

Detailed analysis of these figures yields a fairly complete understanding of the phenomena concerned. Fig. 3 compares the flow over the two profiles at a moderate angle of attack with the flaps up. Examination of the upper surface shows no essential difference in the flow patterns except that the profile with the NACA flap seems to have a slightly later transition than the profile with the Chase flap. This is probably due to the fact that although the slot is supposedly sealed actually a flow does exist as can be seen by carefully examining the figure. On the lower surface the difference is more marked. The flow has a stagnation point on the leading edge of the retracted NACA flap whereas the flow over the under surface of the profile with the Chase flap is completely smooth. Fig. 4 demonstrates these same phenomena at a higher angle of attack. Again the profile with the NACA flap seems to have a smaller region of separation and demonstrates the same stagnation pattern on the leading edge of the retracted flap.

Fig. 5 shows the profiles again at a moderate angle of attack, but now with a 20° flap deflection. The flow over the upper surfaces of the profiles is essentially the same in the two cases with apparently a slightly better flow over the flap equipped with the Chase modification. A large difference in the flow patterns is seen on the lower surface, the flow entering the Chase slot smoothly, but demonstrating a separation at the entrance of the flap slot of the NACA flap. Fig. 6 demonstrates the same flap deflection at a higher angle of attack. There is no essential change in the flow patterns.

Fig. 7 represents the case of moderate angle of attack and 45° flap deflection. The same general characteristics are demonstrated, the flow over the upper surface being essentially equivalent in both cases, but with the Chase modification decreasing the region of stagnation pressures over the under surface of the flap. Figs. 8 to 10 demonstrate the effect of increasing angle of attack. The streamline pattern remains unchanged in its basic characteristics.

Fig. 11 shows the profiles at a zero angle of attack with a 60° flap deflection. In the case of the NACA flap it can be seen that the flow is not attached to the upper surface of the flap while for the Chase flap it is. In this case the Chase configuration is clearly superior in that the flow through the slot gives a local attachment (the main flow is separated). This attachment and restriction of the stagnation region will probably result in a lower drag for a given lift. It will, however, be seen from Fig. 12 that an increase in angle of attack produces a separation over the flap so that the flow pictures for the two cases are again much the same.

4. Conclusions & Recommendations:

As far as can be determined from the smoke tunnel investigations, the flow patterns over a profile equipped with a simply slotted flap and a profile with the Chase modified flap are very nearly the same. The flow over the lower surface of the profile equipped with the Chase flap seems considerably cleaner than that of the NACA flap. However, it is dangerous to conclude that with the flap deflected this will result in a lower drag as the saving will be, at least partially, lost due to the increased skin friction drag caused by the air passing through the long flap tunnel necessitated by the Chase flap design. With the flap retracted the Chase flap gives better lower surface flow. However, as this is a region of favorable pressure gradient and there is no danger of separation the advantages of sealing a gap located towards the rear of the lower surface are bound to be less than fairing a similar gap located on the upper surface.

The conclusion that is reached, then, is that the performance of the two flaps will be very nearly the same. It is probable that the performance of the Chase flap can be still further improved by careful design and development, (possibly by making further use of the smoke tunnel for this purpose) but it will be possible to determine whether or not the added performance is worth the added complexity and weight only by careful and extended wind tunnel measurements.

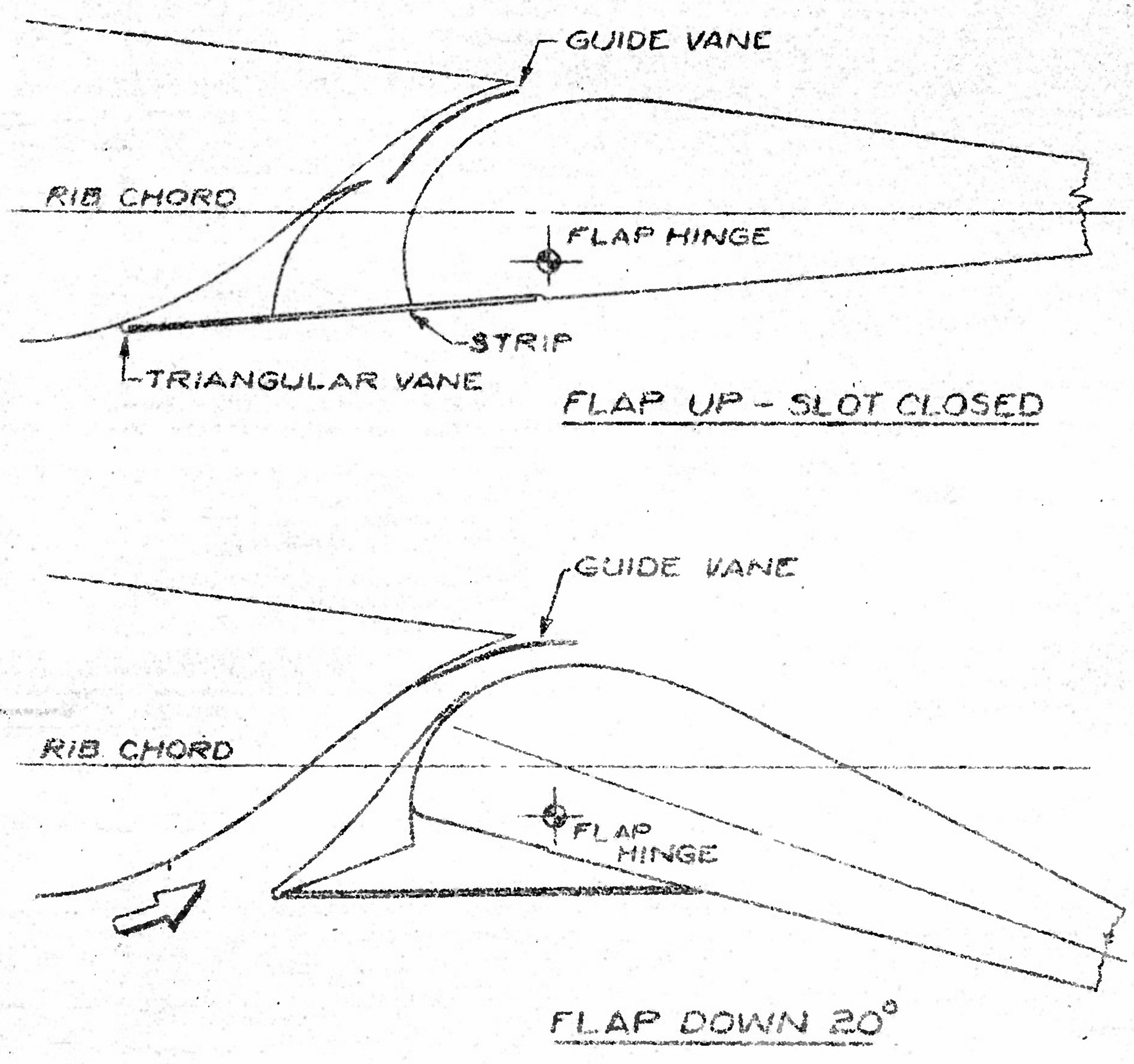
GUIDE VANE
RIB CHORD
FLAP HINGE
STRIP
TRIANGULAR VANE
FLAP UP - SLOT CLOSED
GUIDE VANE
RIB CHORD
FLAP HINGE
FLAP DOWN 20°

FIG. 1

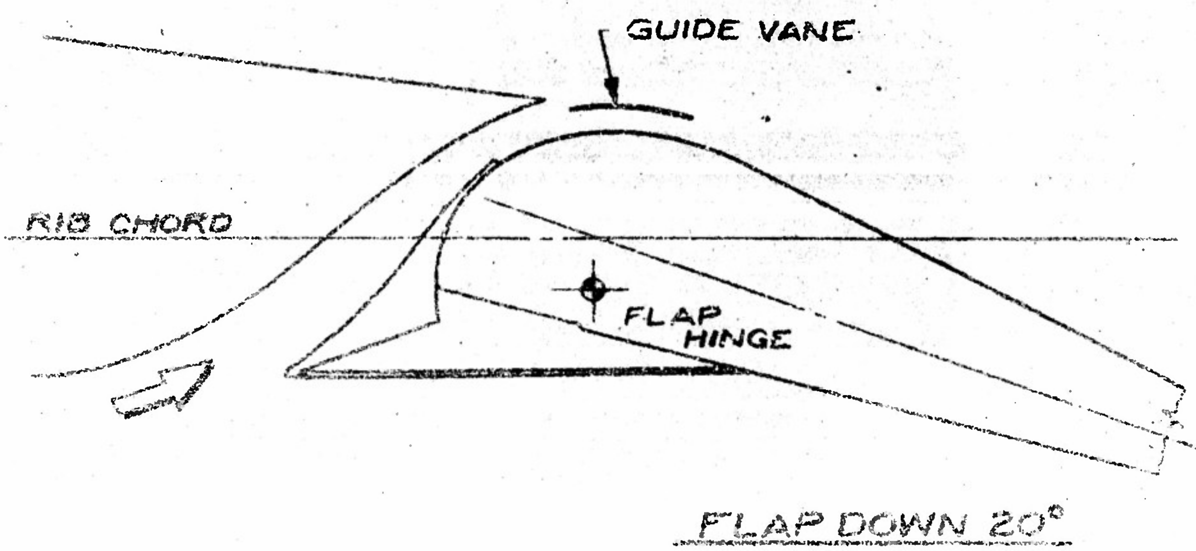


FIG. 2

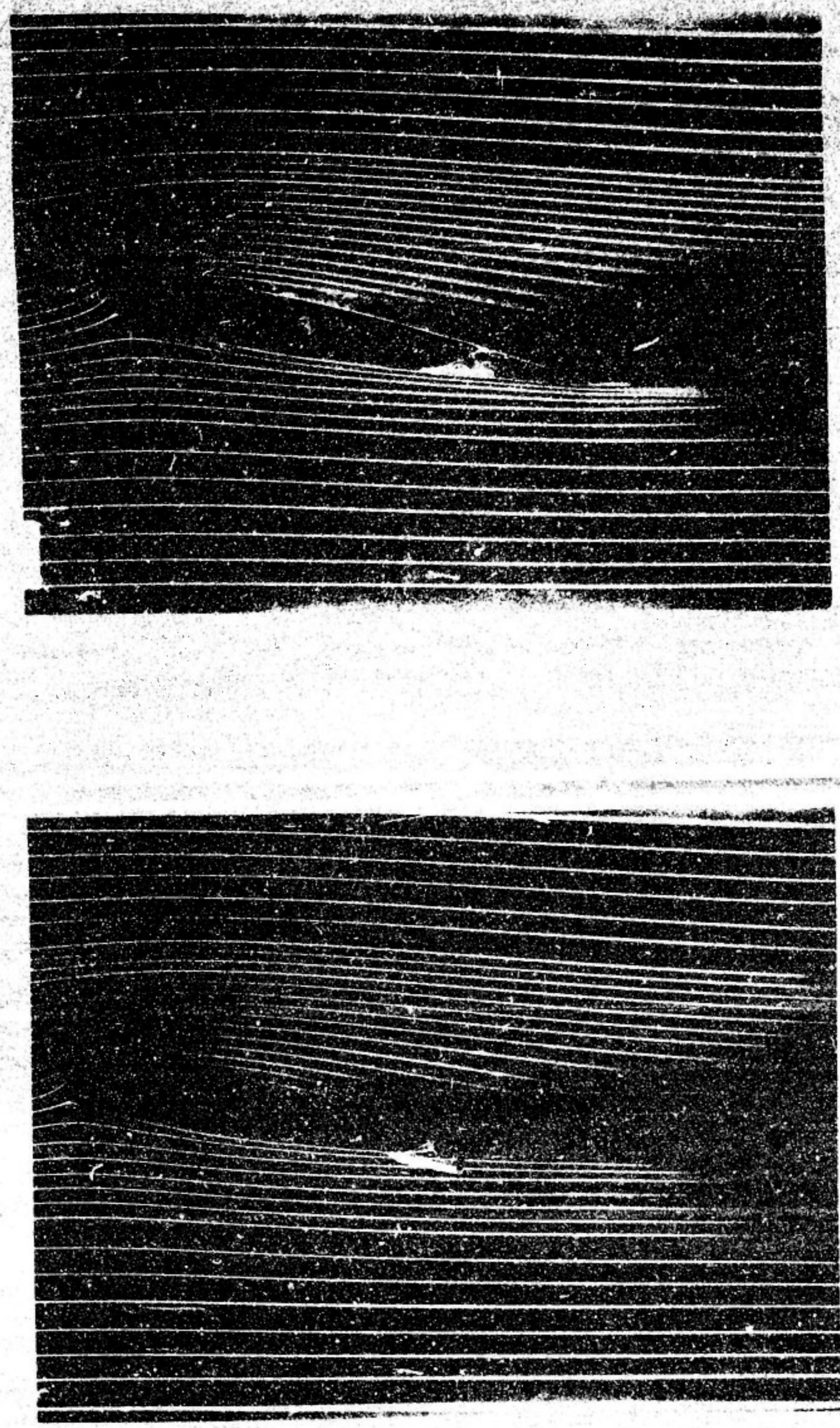

Fig. 3

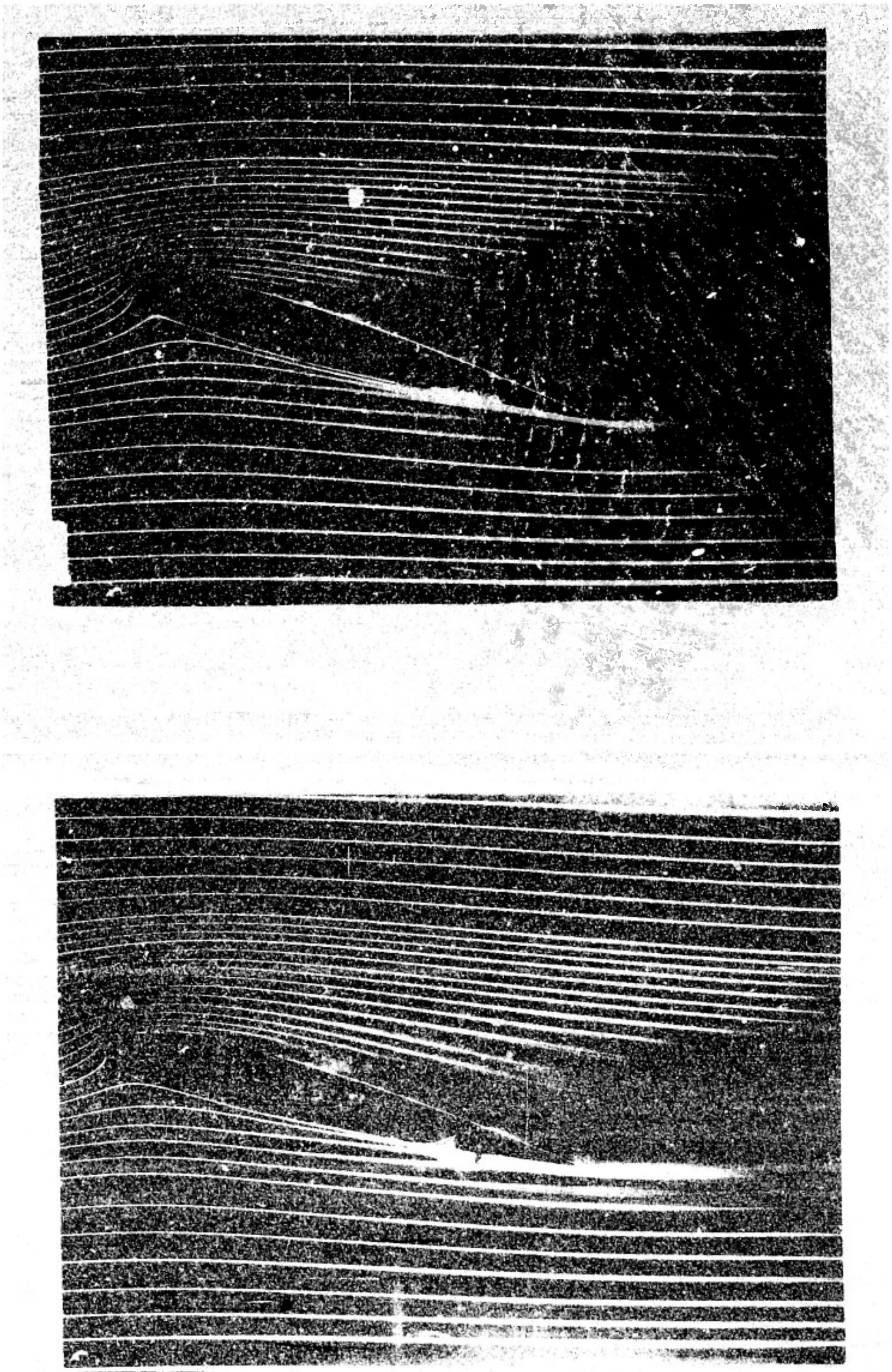

Fig. 4

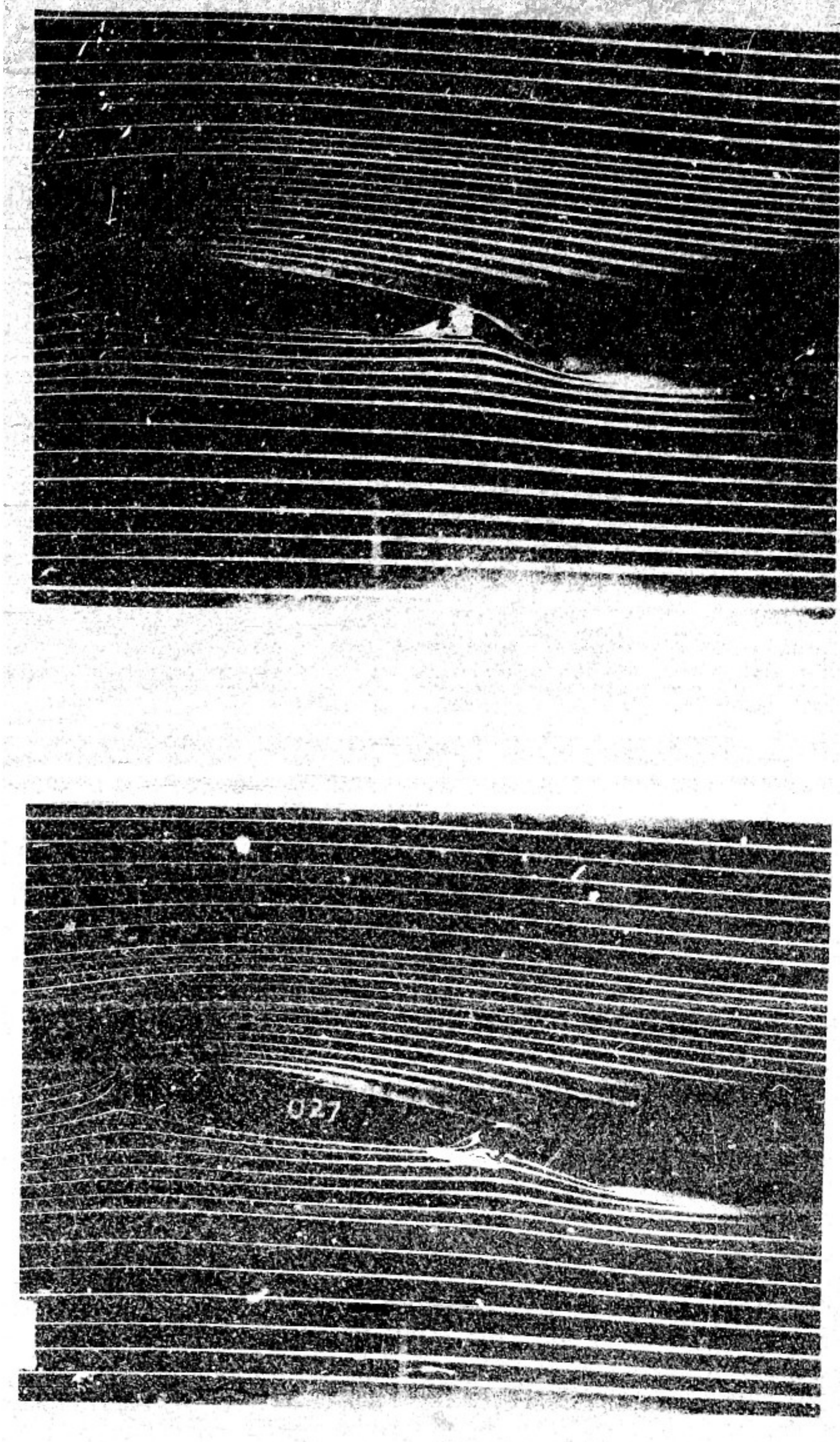


Fig. 5

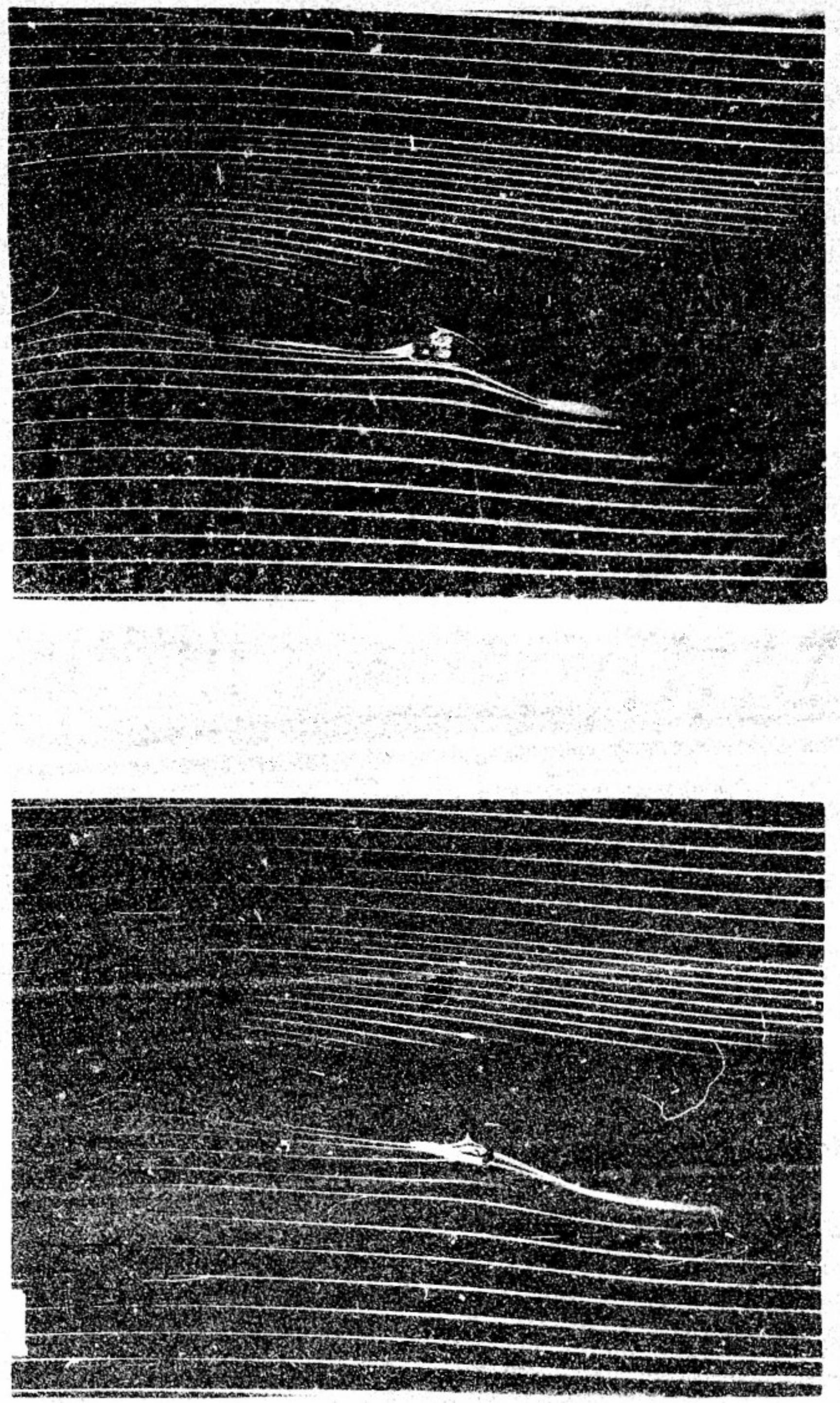

Fig. 6

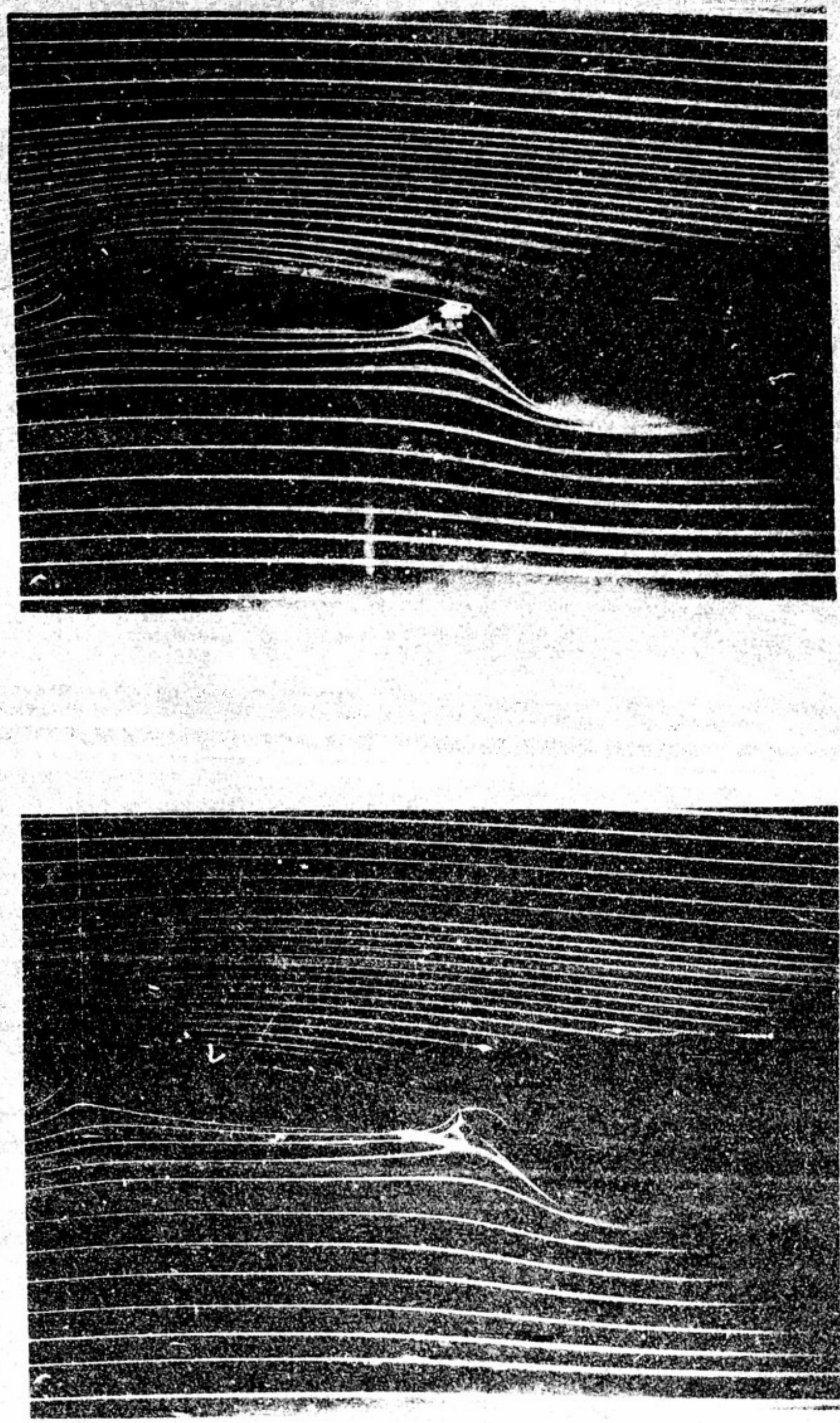

Fig. 7

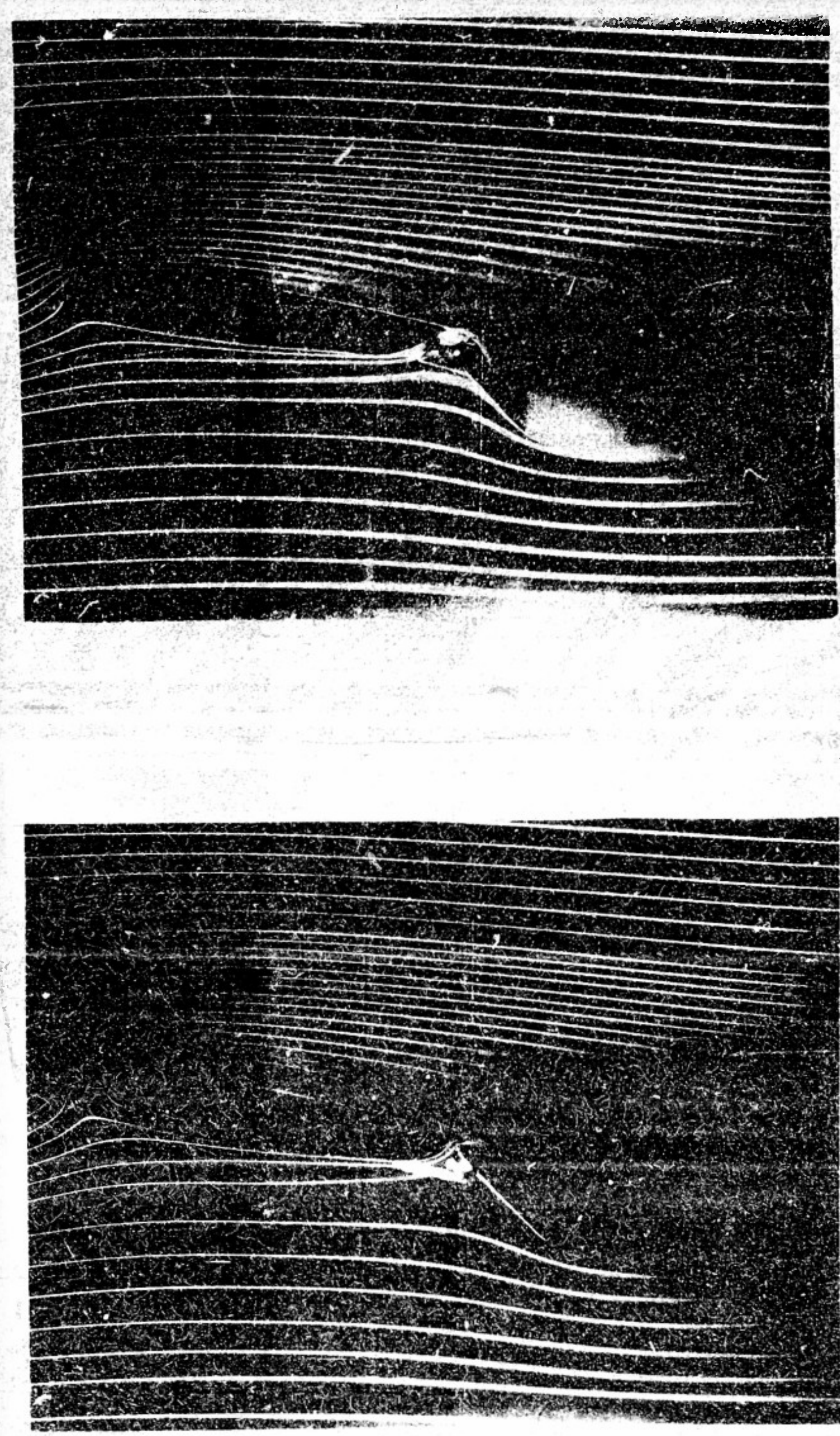

Fig. 6

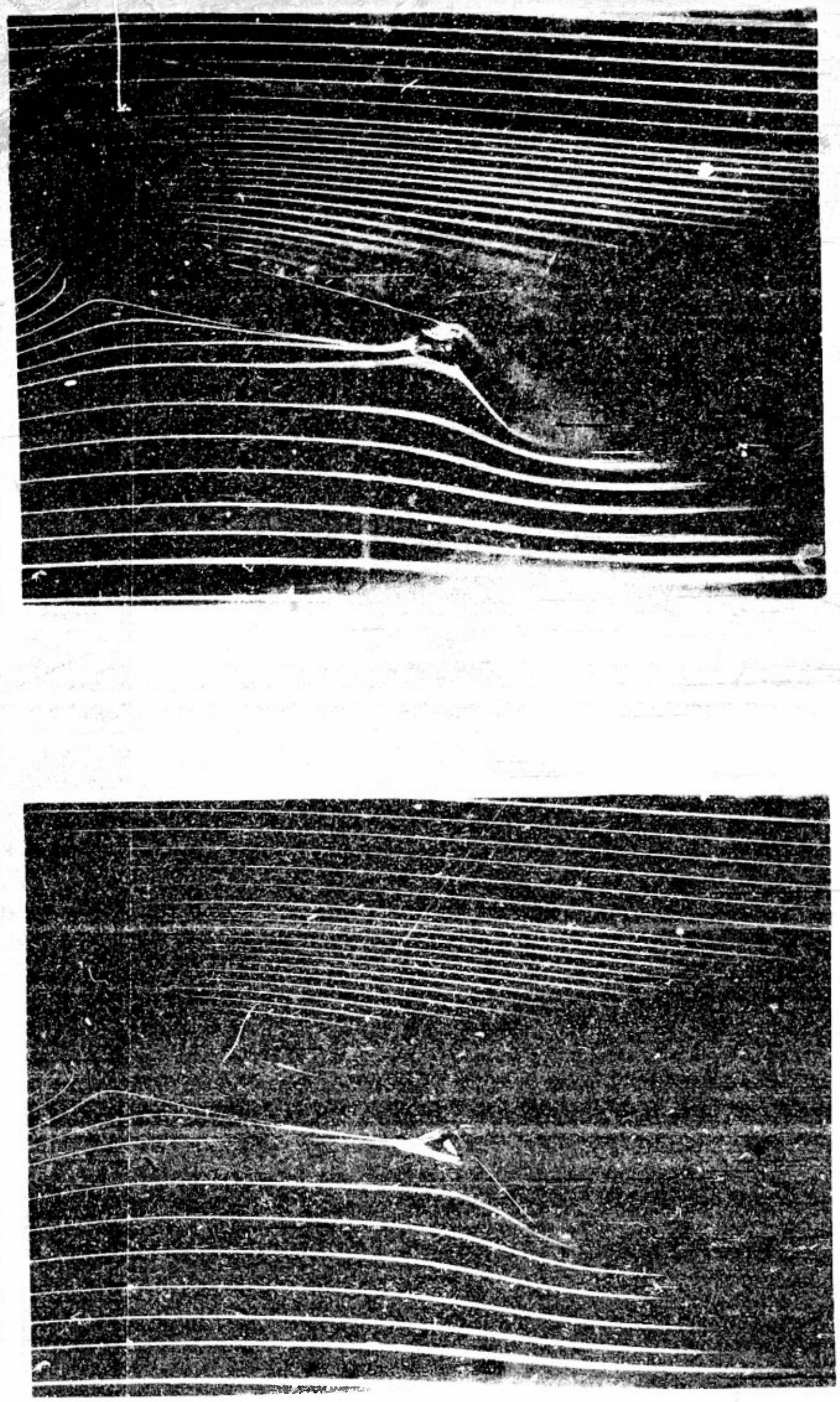

Fig. 9

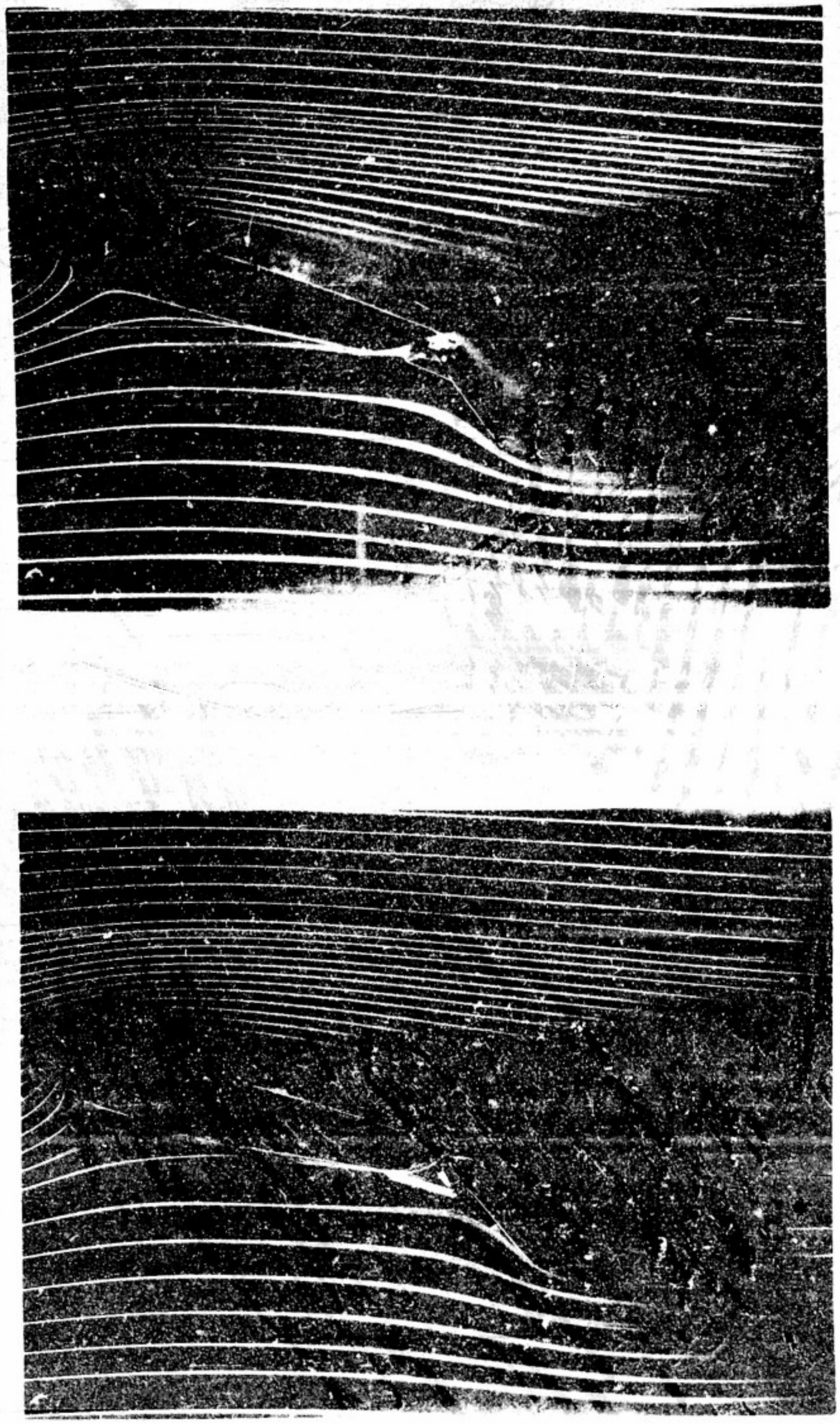

Fig. 10

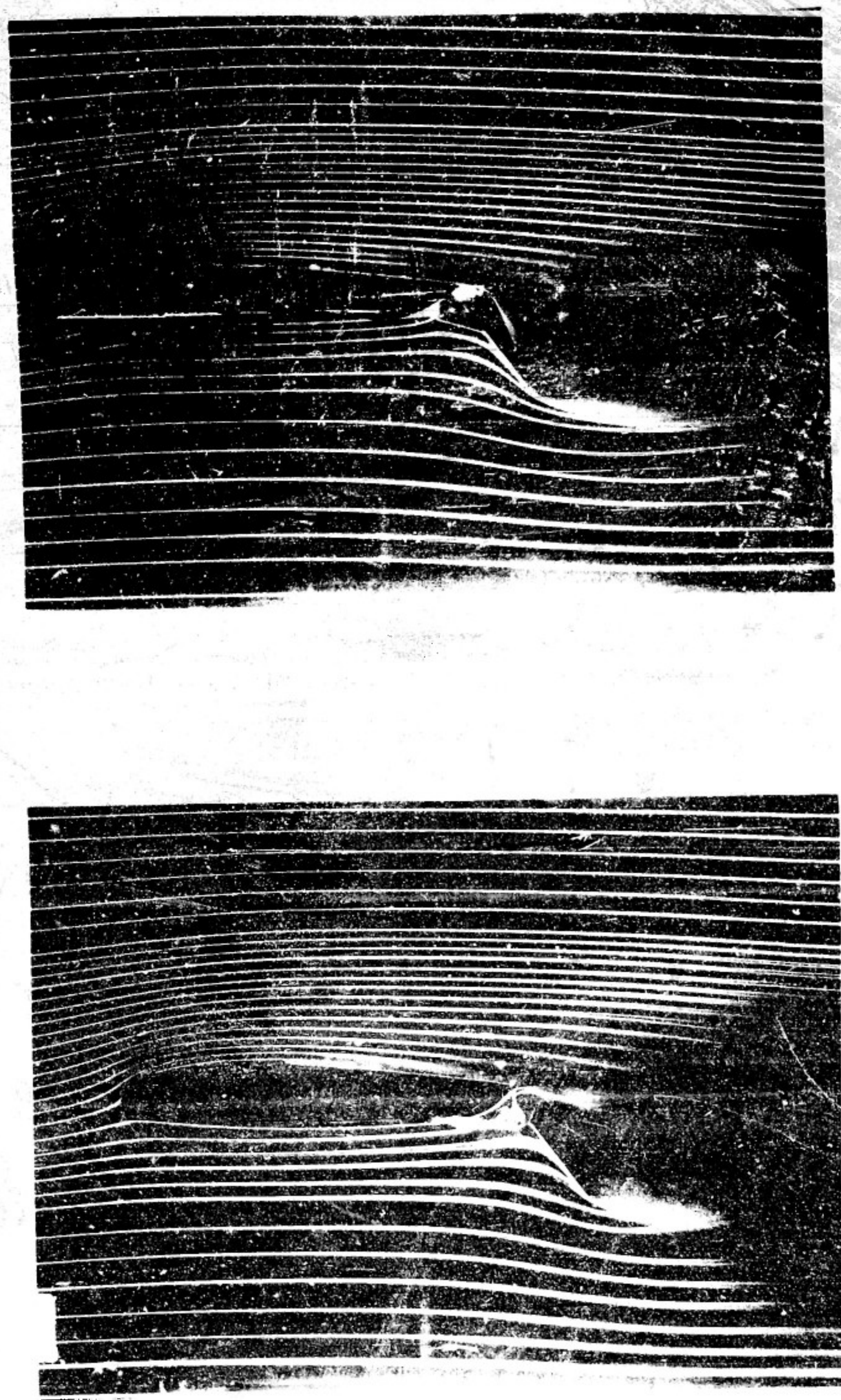

Fig. 11

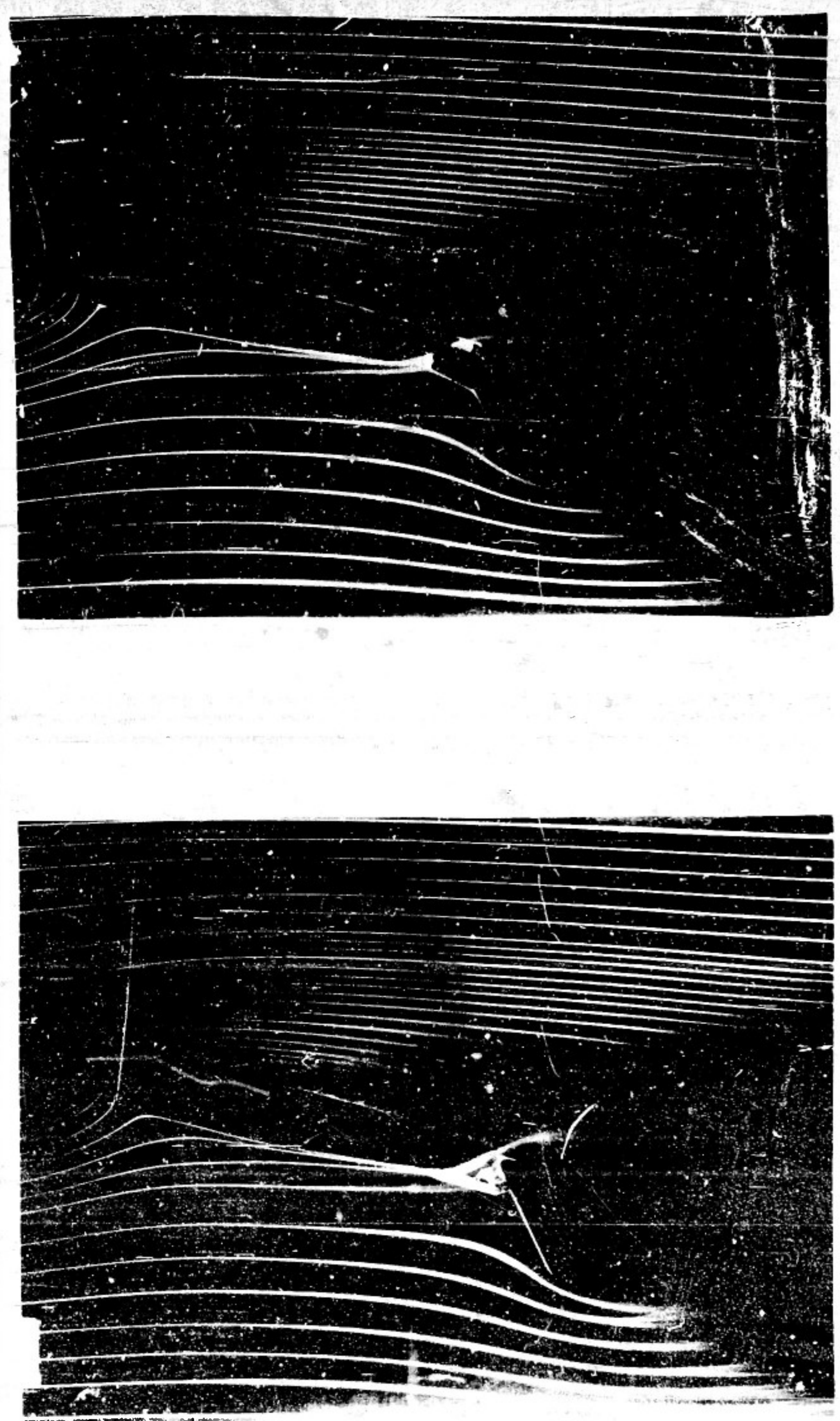

Fig. 12

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